Chapter 1

General Introduction |

BACKGROUND

Definition

The World Health Organization defines overweight and obesity as 'abnormal or excessive fat accumulation that may impair health'. Body mass index (BMI) is a simple measure that is used internationally to classify overweight and obesity, and determine prevalences. It is calculated as weight (in kg) divided by the square of height (in m^2). In adults, cut-off values of 25 kg/m^2 for overweight and of 30 kg/m^2 for obesity are used, based on their associations with future morbidity and mortality.[1] In children, BMI has its limitations, because of the changes in body composition that take place during growth and maturation. However, it has been shown that BMI predicts body fat in children with a sensitivity of 84 to 94% and a specificity of 88 to 93%.[2] In 2000, the International Obesity Task Force defined age and sex specific cut-off points for overweight and obesity in children aged 2 to 18 years that are comparable to the cut-off values in adults (Figure 1).[3] These age and sex specific cut-off values were based on an international survey.

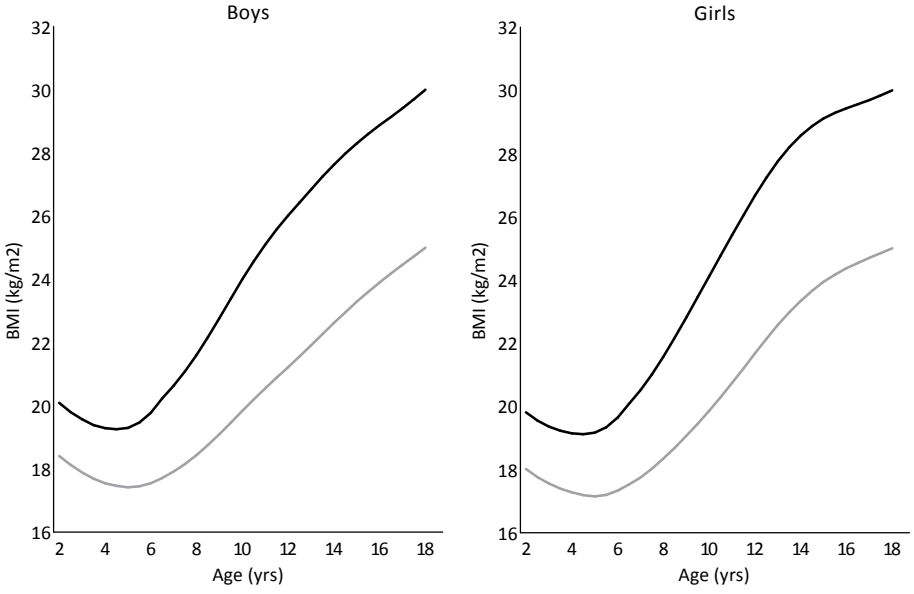


Figure 1. Cut-off values, defined by the International Obesity Task Force, for overweight and obesity in boys and girls.
— overweight
— obesity
Source: Cole et al, BMJ 2000.[3]

Prevalence

From the 1980s, the prevalence of overweight in children and adolescents increased in the Western world. In the United States, the prevalence in adolescents aged 12 to 19 increased from 10.5% in 1989-1994 to 34.4% between 2000 and 2004.[4,5] In the Netherlands, where our studies were conducted, the prevalence trebled between 1980 and 2004 from 3.9% to 14.5% in boys aged 15 years, and from 6.9% to 17.5% in girls aged 15 years (Figures 2a & 2b).[6] Although the prevalence of overweight and obesity in children and adolescents remains very high, recent data suggest that in many countries the rise

Figure 2a. Prevalence of overweight and obesity in Dutch boys.

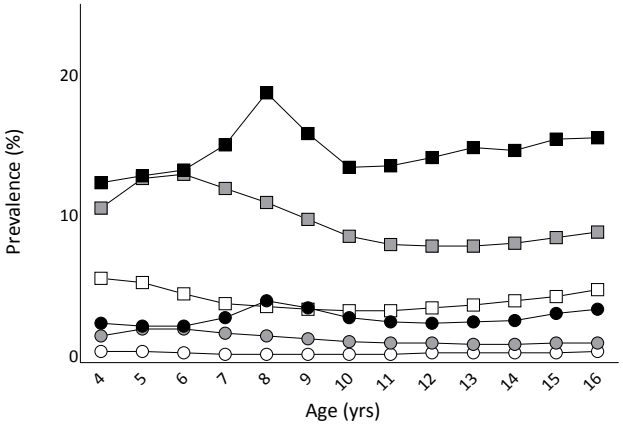
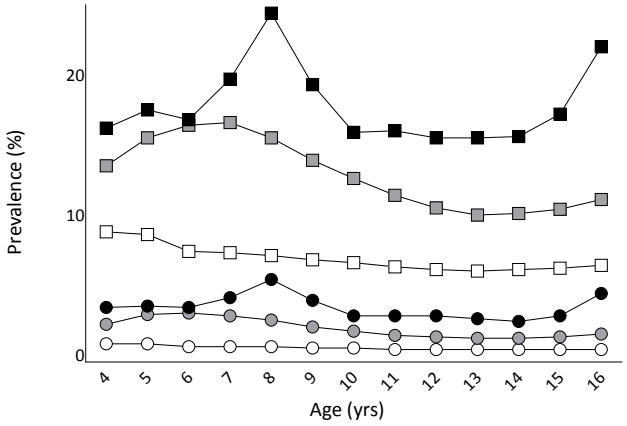


Figure 2b. Prevalence of overweight and obesity in Dutch girls.



■ overweight (including obesity) 2003
■ overweight (including obesity) 1997
□ overweight (including obesity) 1980
● obesity 2003
● obesity 1997
○ obesity 1980

Source: Van den Hurk et al, Arch Dis Child 2007.[6]

in prevalence is leveling off. Data from the USA showed no increase between 1999 and 2010, except among boys in the highest BMI category.[7] A similar trend was found in the Netherlands[8] and in France.[9] Two Swedish studies reported no significant increase in boys and a decreasing trend in girls, although prevalences remain much higher than in the 1980s.[10,11] These studies emphasized the persistently higher prevalence of overweight and obesity in socioeconomically deprived areas, which remains of concern. Especially in boys, an increase in social disparity was observed.[11]

Several possible explanations for the stabilization in prevalence can be hypothesized.[9] Public awareness has increased regarding the detrimental effects of childhood overweight on physical and mental health. Alternatively, it is possible that the prevalence has reached a plateau considering the population distribution of genetic, environmental and specifically socioeconomic risk factors for childhood overweight.

Risk factors

Social changes explaining the increased prevalence of overweight and obesity are multiple, such as larger portion sizes, increased sedentary recreation and use of motorized transport.[12] On an individual level, risk factors for childhood overweight can be broadly divided into six groups: (1) genetic / inheritance, (2) social factors, (3) growth, development and programming, (4) physical and sedentary activities, (5) dietary factors, and (6) behavioral and psychological factors.

1. Genetic / inheritance

Parental overweight is associated with an increased risk of childhood overweight (odds ratios vary from 2.1 to 2.9), independent of other important risk factors in early life such as birth weight and socioeconomic status (SES).[13] Recently, genome wide association studies in large cohorts have identified common variants associated with overweight, most importantly variants in *FTO* (*fat mass and obesity associated*) and near *MC4R* (*melanocortin-4 receptor*) genes.[14,15]

Few studies have investigated the role of genetic variants in childhood overweight and its associated metabolic traits. It would be interesting to evaluate these associations in a population-based cohort.

2. Social factors

Most studies conducted in developed countries showed an inverse association between SES and overweight.[16] Additionally, a higher prevalence of overweight has been reported in children of single parents and in children living in urban compared with rural areas.[17] Evidence for ethnic differences was found in studies from the USA which showed that

African Americans, Mexican Americans, and Native Americans have an increased risk of becoming overweight.[18] In the Netherlands, children from Turkish origin showed the highest prevalence of overweight.[8] Ethnic differences can be ascribed to socioeconomic differences, but genetic and cultural influences are also important.[18]

3. Growth, development and programming

It has been reported that critical time periods exist in which accelerated growth represents a risk factor for subsequent overweight.[19] Specifically, these include intra-uterine development, early infancy, the period of adiposity rebound, and adolescence.

- Birth weight has been studied as a proxy for intra-uterine development. A consistent positive association was found.[13] More recently, a J-shaped relationship was suggested, but little attempt was made to adjust for potential confounders such as gestational age, parental fatness, and SES.[20] Birth weight could be influenced by maternal overweight and gestational diabetes,[17] maternal smoking,[21] and famine.[22]
- It has been reported that rapid infant (or early childhood) growth is associated with an increased risk of subsequent overweight in adolescence and adulthood.[23-25]
- The period of adiposity rebound, between ages 4 and 7 years, has also been described as important in the development of overweight in later life.[26] Timing of the adiposity rebound was found to be associated with adult overweight, independent of BMI at the start of the adiposity rebound.[26]
- Early maturation during puberty is also associated with an increased risk of subsequent overweight.[20]

It would be interesting to evaluate which periods of infant or childhood growth are most important in the development of overall and abdominal adiposity in adolescence. Additional analyses could determine if the magnitude of the associations between growth in critical periods and overweight in adolescence is different dependent on smoking during pregnancy.

4. Physical and sedentary activities

It is well known that low levels of physical activity and high levels of sedentary activity increase the risk of overweight.[27,28] Studies regarding physical activity consistently report that low levels are associated with childhood overweight, except in the youngest age groups.[27] Research on sedentary behaviors show inconsistent positive associations and small effect sizes, with stronger associations in preadolescent children.[27,29]

5. Dietary factors

Studies concerning dietary factors can be divided into two groups: those studying infant feeding, particularly breastfeeding; and studies on dietary intake in childhood. Breastfeed-

ing might influence early growth,[30,31] but it probably does not contribute greatly to subsequent overweight, certainly not after adjustment for socioeconomic characteristics.[31] The small effects that were reported, might have been due to differences in feeding style associated with breastfeeding.[32] Research on the longitudinal association between dietary intake and subsequent overweight did not result in clear evidence for a causal relationship.[20,33] Studies were often limited in sample size and hampered by difficulties in measurement of dietary intake. Although there is insufficient evidence to determine the effectiveness of school-based dietary interventions to prevent overweight, some studies suggest a positive influence on BMI, at least in the short term.[34] Evidence was found for sweetened beverages as risk factor for overweight,[32,35,36] which could be explained by increased fructose consumption.[35] Fructose consumption leads to increased triglycerides, lipogenesis, and blood pressure; and has a smaller effect on leptin and insulin release in comparison with similar amounts of glucose.

6. Behavioral and psychological factors

Difficult temperament in infancy and childhood has been associated with subsequent overweight.[37] Other behavioral predictors include parental control of feeding (restriction of food intake might lead to overweight in high risk groups)[38] and sleep duration. A meta-analysis showed that sleep duration and overweight were inversely associated, although results were inconsistent in adolescent girls.[39] Nevertheless, both observational and experimental evidence suggest that an association between short sleep duration and overweight exists.[40] Impulsivity has also been associated with overweight,[41] but most research has been performed in clinical samples of overweight children seeking treatment, which limits generalizability to the overall population.[42]

Psychological predictors include anxiety[43] and depressive symptoms. Depressive symptoms have been described as a predictor and as a consequence of overweight, primarily in adults but also in adolescents.[44] In contrast to the common idea that overweight might lead to unhappiness and depressive symptoms, recent reports suggest that depressive symptoms could also precede overweight and consequently predict development of overweight.[44]

It would be important to know if childhood depressive symptoms are also associated with abdominal adiposity and its related metabolic traits in adolescence.
Studies regarding the association between impulsive traits and overweight in population-based cohorts are scarce.[42] It would be interesting to evaluate whether genetic variation in impulsivity related genes underlies the differences in impulsive personality characteristics; and if so, whether these differences also lead to differential risk for overweight.

Implications and consequences

Childhood overweight is a major public health concern because it is associated with overweight and cardiovascular morbidity and mortality in later life.[45,46] Although population attributable risk calculations showed that less than half of adult overweight can be attributed to childhood overweight, correlations between childhood and adult BMI increase with age and BMI of the child; and overweight in school-aged children has a positive predictive value of 42 to 63% in predicting adult overweight.[47] In addition, overweight in childhood and adolescence has been associated with development of the metabolic syndrome, a cluster of cardiovascular risk factors, in adulthood.[48,49] Adolescent overweight is associated with an increased risk of not only cardiovascular mortality, but also of death due to colon cancer, and endocrine, nutritional and metabolic diseases.[46] Overweight in childhood and adolescence has also been related to sleep apnea, polycystic ovary disease, and various orthopedic problems.[48] In terms of mental health, social stigmatization and isolation are known consequences of overweight.[48] Obese adolescents tend to develop a negative self-image which appears to persist into adulthood.

Already in childhood, overweight is associated with development of the metabolic syndrome, consisting of a cluster of cardiovascular risk factors. In line with the definition of the metabolic syndrome in adults, several research groups have developed criteria for children based on abdominal obesity, dyslipidemia, glucose intolerance and hypertension. In 2007, age-adjusted criteria were defined by the International Diabetes Federation (IDF). However, there is still no consensus on which criteria are most suitable.[50] Studies applying various criteria reported a wide variation of prevalences. It is clear that the prevalence is increased in overweight children. Although the existence of exact cut-off values for normal versus pathological remain controversial, it is evident that abnormalities in the components of the metabolic syndrome already start in childhood.[51] However, the construct stability of the metabolic syndrome is limited and insufficient evidence exists on the predictive value of childhood metabolic syndrome for adult cardiovascular disease. Therefore, the usefulness of the 'metabolic syndrome' as a construct in children remains under debate.[51]

Adolescence

One of the critical time periods, in which accelerated growth presents a risk factor for subsequent overweight, is adolescence. Adolescence is a decisive period in human life because of the multiple changes that occur between childhood and adulthood. Puberty is the primary neurohormonal determinant of both physiological and psychological changes, although social and behavioral factors must also be considered in this process.[2] Indeed, many important determinants for overweight will change in adolescence. For example, depressive symptoms become more common, increasing the likelihood of a simultaneous occurrence. This raises questions about a possible association or common cause, as described

in an early review article on obesity-depression associations in the population.[44] Moreover, lifestyle changes occur, influencing time spent in physical and sedentary activities.

During puberty, sex-specific changes in body composition occur. Fat mass increases both in girls and in boys, but in boys this increase ceases earlier and even reverses temporarily. Therefore, girls tend to accumulate more fat mass during adolescence.[12] Pubertal development is also associated with accrual of visceral fat and development of insulin resistance. Therefore, adolescence is an important period for studying associations between behavioral factors, body fat, and metabolic traits.[48]

POPULATION & MEASURES

Most of the research described in this thesis was performed among adolescents participating in the TRAILS (TRacking Adolescents' Individual Lives Survey) study, a population-based cohort study assessing psychosocial and physical health from preadolescence into adulthood.[52,53] Sample selection entailed two stages (Figure 3). First, personal information (i.e. name, date of birth, sex, and address) was requested through community registers on all inhabitants of five communities in the three northern provinces of the Netherlands, who were born between 10-01-1989 and 09-30-1990 (first two municipalities) or between 10-01-1990 and 09-30-1991 (last three municipalities) (n=3483). Simultaneously, all primary schools attended by these children were asked to participate, to allow for measurement visits and participation of teachers in the questionnaires. Since school participation

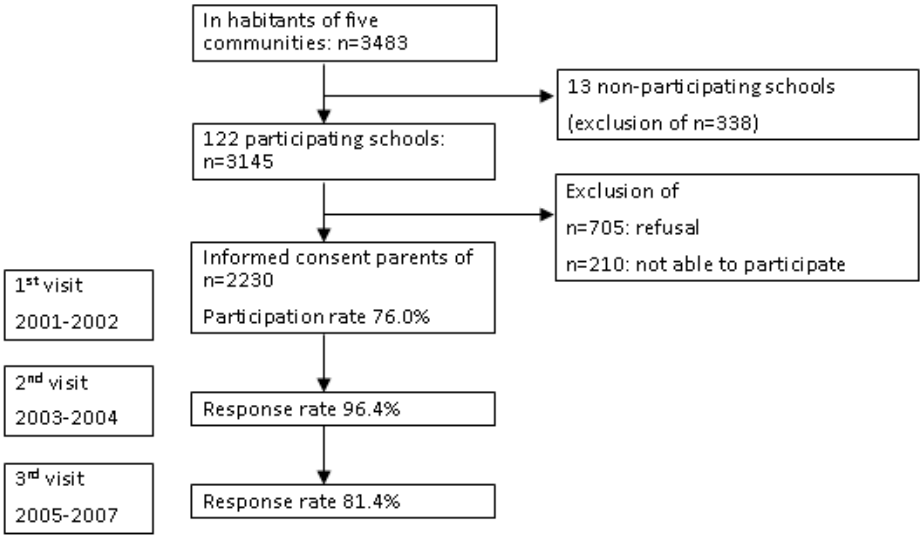


Figure 3. Study population.

was a prerequisite for eligible children and parents to be approached, 338 children were excluded from schools which refused participation. The second stage involved informing parents and children through brochures and school visits. Parents were contacted by telephone to ask whether they and their son or daughter were willing to participate in the study. Respondents with an unlisted telephone number were approached through mail and home visits. Children were excluded from the study if they were incapable of participating because of mental retardation or a serious physical illness or handicap, or if no Dutch-speaking parent or parent surrogate was available and it was not feasible to administer any of the measurements in the parents' language (n=210). Of the remaining 2935 children, 76.0% (n= 2230; mean age = 11.1 years, standard deviation (SD) = 0.6; 50.8% girls) were enrolled in the study after extensive recruitment efforts. Written informed consent was obtained from parents.

The baseline assessment visit took place from March 2000 until July 2001. It consisted primarily of questionnaires on mental and physical health and lifestyle (filled out by child, parents, and teacher) and a parent interview to collect information on, amongst others, sociodemographic characteristics, developmental history, and general health of the child. In addition, weight, height and skinfold thicknesses were obtained. From September 2003 to December 2004, the second measurement visit was conducted, in which 96.4% of all baseline participants (n =2149; mean (± SD) age 13.6 ± 0.5 years; 51.0% girls) participated. To minimize loss to follow-up, this assessment visit was limited to questionnaires and measurement of weight and height. The third assessment visit, which took place from October 2005 until December 2007, was more extensive. Apart from weight, height, and skinfold thicknesses, additional anthropometric measurements were performed including waist circumference and hand-to-foot bioelectrical impedance analysis, from which percentage body fat (%BF) was calculated. Moreover, blood pressure was measured. A blood sample was obtained after at least 8 hours of fasting for DNA isolation; and for measurement of, amongst others, glucose, insulin, cholesterol, and triglycerides.

In collaboration with the Department of Health Sciences, previous growth data, including birth weight and birth length, recorded at well-child clinics were collected of 1669 participants. This represents 74.8% of the original cohort, because not all records could be traced (n=239, 10.7%), and not all participants gave informed consent to extract these data (n=322, 14.4%).

AIMS AND OUTLINE

The main aim of this thesis was to investigate risk factors for the development of overweight in adolescence. We focused on individual risk factors rather than cultural and

social factors or policy on municipal and national levels. A second aim was to compare and validate various measurement methods of overall and abdominal adiposity in children.

In the first part of this thesis we describe risk factors for overweight in adolescence. In chapter 2, we focus on genetic factors. Chapter 2.1 describes the role of common genetic variants on overweight and metabolic profile. In chapter 2.2, we evaluate the genetic influence on impulsivity and overweight. In chapter 3, we focus on important periods of childhood growth for overweight in adolescence. Chapter 4 starts with a review of the literature regarding depressive symptoms in childhood as a predictor for overweight in later life (chapter 4.1). In chapter 4.2, we describe our own findings regarding the longitudinal association between depressive symptoms and overweight.

The second part of this thesis consists of two studies on measurements of body composition in prepubertal children. Although BMI is easy to obtain and very reliable, it does not differentiate between lean body mass and fat mass. The most reliable measures for total body fat are multicompartment models, underwater weighing, doubly labeled water, and dual-energy X-ray absorptiometry (DEXA); and for abdominal fat computed tomography (CT) and magnetic resonance imaging (MRI).[51] However, these methods are not suitable for large epidemiological studies because of high costs and limited accessibility. In large study populations, it is important to use valid but practically applicable measures of total and abdominal fat. We compare various measurements of total body fat chapter 5.1. Chapter 5.2 describes the validation of measurements of abdominal adiposity.

We compare and discuss the various determinants for adolescent overweight in chapter 6. We discuss pitfalls and implications for public health strategies. We also offer suggestions for the direction of future research.

REFERENCES

1. World Health Organisation. Obesity: Preventing and managing the Global Epidemic - Report of a WHO Consultation on Obesity, 3-5 June 1997, Geneva, WHO/NUT/NCD/98.1.https://apps.who.int/nut/documents/obesity_executive_summary.pdf. Accessed November 13th 2009.
2. Rodriguez G, Moreno LA, Blay MG, Blay VA, Garagorri JM, Sarria A, and Bueno M. Body composition in adolescents: measurements and metabolic aspects. Int J Obes Relat Metab Disord 2004;28 Suppl 3:S54-8.
3. Cole TJ, Bellizzi MC, Flegal KM, and Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. BMJ 2000;320(7244):1240-3.
4. Ogden CL, Flegal KM, Carroll MD, and Johnson CL. Prevalence and trends in overweight among US children and adolescents, 1999-2000. JAMA 2002;288(14):1728-32.
5. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, and Flegal KM. Prevalence of overweight and obesity in the United States, 1999-2004. JAMA 2006;295(13):1549-55.
6. Van den Hurk K, van Dommelen P, Van Buuren S, Verkerk PH, and Hirasing RA. Prevalence of overweight and obesity in the Netherlands in 2003 compared to 1980 and 1997. Arch Dis Child 2007;92(11):992-5.
7. Ogden CL, Carroll MD, Curtin LR, Lamb MM, Flegal KM. Prevalence of high body mass index in US children and adolescents, 2007-2008. JAMA 2010;303(3):242-9.
8. De Wilde JA, Van Dommelen P, Middelkoop BJ, and Verkerk PH. Trends in overweight and obesity prevalence in Dutch, Turkish, Moroccan and Surinamese South Asian children in the Netherlands. Arch Dis Child 2009;94(10):795-800.
9. Peneau S, Salanave B, Maillard-Teyssier L et al. Prevalence of overweight in 6- to 15-year-old children in central/western France from 1996 to 2006: trends toward stabilization. Int J Obes (Lond) 2009;33(4):401-7.
10. Sjoberg A, Lissner L, Albertsson-Wikland K, and Marild S. Recent anthropometric trends among Swedish school children: evidence for decreasing prevalence of overweight in girls. Acta Paediatr 2008;97(1):118-23.
11. Sundblom E, Petzold M, Rasmussen F, Callmer E, and Lissner L. Childhood overweight and obesity prevalences levelling off in Stockholm but socioeconomic differences persist. Int J Obes (Lond) 2008;32(10):1525-30.
12. Lobstein T, Baur L, Uauy R; IASO International Obesity Task Force. Obesity in children and young people: a crisis in public health. Obes Rev 2004;5 Suppl 1:4-104.
13. Danielzik S, Czerwinski-Mast M, Langnase K, Dilba B, and Muller MJ. Parental overweight, socioeconomic status and high birth weight are the major determinants of overweight and obesity in 5-7 y-old children: baseline data of the Kiel Obesity Prevention Study (KOPS). Int J Obes Relat Metab Disord 2004;28(11):1494-1502.
14. Frayling TM, Timpson NJ, Weedon MN et al. A common variant in the FTO gene is associated with body mass index and predisposes to childhood and adult obesity. Science 2007;316(5826):889-94.
15. Loos RJ, Lindgren CM, Li S et al. Common variants near MC4R are associated with fat mass, weight and risk of obesity. Nat Genet 2008;40(6):768-75.
16. Shrewsbury V and Wardle J. Socioeconomic status and adiposity in childhood: a systematic review of cross-sectional studies 1990-2005. Obesity (Silver Spring) 2008;16(2):275-84.
17. Kipping RR, Jago R, and Lawlor DA. Obesity in children. Part 1: Epidemiology, measurement, risk factors, and screening. BMJ 2008;337:a1824.

18. Caprio S, Daniels SR, Drewnowski A et al. Influence of race, ethnicity, and culture on childhood obesity: implications for prevention and treatment: a consensus statement of Shaping America's Health and the Obesity Society. Diabetes Care 2008;31(11):2211-21.
19. Dietz WH. Critical periods in childhood for the development of obesity. Am J Clin Nutr 1994;59(5):955-9.
20. Parsons TJ, Power C, Logan S, and Summerbell CD. Childhood predictors of adult obesity: a systematic review. Int J Obes Relat Metab Disord 1999;23 Suppl 8:S1-107.
21. Karaolis-Danckert N, Buyken AE, Kulig M et al. How pre- and postnatal risk factors modify the effect of rapid weight gain in infancy and early childhood on subsequent fat mass development: results from the Multicenter Allergy Study 90. Am J Clin Nutr 2008;87(5):1356-64.
22. Ravelli GP, Stein ZA, and Susser MW. Obesity in young men after famine exposure in utero and early infancy. N Engl J Med 1976;295(7):349-53.
23. Baird J, Fisher D, Lucas P, Kleijnen J, Roberts H, and Law C. Being big or growing fast: systematic review of size and growth in infancy and later obesity. BMJ 2005;331(7522):929.
24. Monteiro PO and Victora CG. Rapid growth in infancy and childhood and obesity in later life--a systematic review. Obes Rev 2005;6(2):143-54.
25. Ong KK and Loos RJ. Rapid infancy weight gain and subsequent obesity: systematic reviews and hopeful suggestions. Acta Paediatr 2006;95(8):904-8.
26. Whitaker RC, Pepe MS, Wright JA, Seidel KD, and Dietz WH. Early adiposity rebound and the risk of adult obesity. Pediatrics 1998;101(3):E5.
27. Must A and Tybor DJ. Physical activity and sedentary behavior: a review of longitudinal studies of weight and adiposity in youth. Int J Obes (Lond) 2005;29 Suppl 2:S84-96.
28. Bar-Or O, Foreyt J, Bouchard C et al. Physical activity, genetic, and nutritional considerations in childhood weight management. Med Sci Sports Exerc 1998;30(1):2-10.
29. Marshall SJ, Biddle SJ, Gorely T, Cameron N, and Murdey I. Relationships between media use, body fatness and physical activity in children and youth: a meta-analysis. Int J Obes Relat Metab Disord 2004;28(10):1238-46.
30. Griffiths LJ, Smeeth L, Hawkins SS, Cole TJ, and Dezateux C. Effects of infant feeding practice on weight gain from birth to 3 years. Arch Dis Child 2009;94(8):577-82.
31. Scholtens S, Gehring U, Brunekreef B et al. Breastfeeding, weight gain in infancy, and overweight at seven years of age: the prevention and incidence of asthma and mite allergy birth cohort study. Am J Epidemiol 2007;165(8):919-26.
32. Agras WS and Mascola AJ. Risk factors for childhood overweight. Curr Opin Pediatr 2005;17(5):648-52.
33. Moreno LA, Ochoa MC, Warnberg J, Marti A, Martinez JA, and Marcos A. Treatment of obesity in children and adolescents. How nutrition can work? Int J Pediatr Obes 2008;3 Suppl 1:72-7.
34. Brown T and Summerbell C. Systematic review of school-based interventions that focus on changing dietary intake and physical activity levels to prevent childhood obesity: an update to the obesity guidance produced by the National Institute for Health and Clinical Excellence. Obes Rev 2009;10(1):110-41.
35. Bray GA. Soft drink consumption and obesity: it is all about fructose. Curr Opin Lipidol 2010;21(1):51-7.
36. Fiorito LM, Marini M, Francis LA, Smiciklas-Wright H, and Birch LL. Beverage intake of girls at age 5 y predicts adiposity and weight status in childhood and adolescence. Am J Clin Nutr 2009;90(4):935-42.
37. Carey WB, Hegvik RL, and McDevitt SC. Temperamental factors associated with rapid weight gain and obesity in middle childhood. J Dev Behav Pediatr 1988;9(4):194-8.

38. Faith MS, Berkowitz RI, Stallings VA, Kerns J, Storey M, and Stunkard AJ. Parental feeding attitudes and styles and child body mass index: prospective analysis of a gene-environment interaction. Pediatrics 2004;114(4):e429-36.
39. Chen X, Beydoun MA, and Wang Y. Is sleep duration associated with childhood obesity? A systematic review and meta-analysis. Obesity (Silver Spring) 2008;16(2):265-74.
40. Van Cauter E and Knutson KL. Sleep and the epidemic of obesity in children and adults. Eur J Endocrinol 2008;159 Suppl 1:S59-66.
41. Nederkoorn C, Braet C, Van EY, Tanghe A, and Jansen A. Why obese children cannot resist food: the role of impulsivity. Eat Behav 2006;7(4):315-22.
42. Braet C, Claus L, Verbeken S, and Van Vlierberghe L. Impulsivity in overweight children. Eur Child Adolesc Psychiatry 2007;16(8):473-83.
43. Anderson SE, Cohen P, Naumova EN, and Must A. Association of depression and anxiety disorders with weight change in a prospective community-based study of children followed up into adulthood. Arch Pediatr Adolesc Med 2006;160(3):285-91.
44. Faith MS, Matz PE, and Jorge MA. Obesity-depression associations in the population. J Psychosom Res 2002;53(4):935-42.
45. Mahoney LT, Burns TL, Stanford W et al. Coronary risk factors measured in childhood and young adult life are associated with coronary artery calcification in young adults: the Muscatine Study. J Am Coll Cardiol 1996;27(2):277-84.
46. Bjorge T, Engeland A, Tverdal A, and Smith GD. Body mass index in adolescence in relation to cause-specific mortality: a follow-up of 230,000 Norwegian adolescents. Am J Epidemiol 2008;168(1):30-7.
47. Serdula MK, Ivery D, Coates RJ, Freedman DS, Williamson DF, and Byers T. Do obese children become obese adults? A review of the literature. Prev Med 1993;22(2):167-77.
48. Dietz WH. Health consequences of obesity in youth: childhood predictors of adult disease. Pediatrics 1998;101(3 Pt 2):518-25.
49. Sun SS, Liang R, Huang TT et al. Childhood obesity predicts adult metabolic syndrome: the Fels Longitudinal Study. J Pediatr 2008;152(2):191-200.
50. Zimmet P, Alberti G, Kaufman F et al. The metabolic syndrome in children and adolescents. Lancet 2007;369(9579):2059-61.
51. Steinberger J, Daniels SR, Eckel RH et al. Progress and challenges in metabolic syndrome in children and adolescents: a scientific statement from the American Heart Association Atherosclerosis, Hypertension, and Obesity in the Young Committee of the Council on Cardiovascular Disease in the Young; Council on Cardiovascular Nursing; and Council on Nutrition, Physical Activity, and Metabolism. Circulation 2009;119(4):628-47.
52. Huisman M, Oldehinkel AJ, de Winter A et al. Cohort profile: the Dutch 'TRacking Adolescents' Individual Lives' Survey'; TRAILS. Int J Epidemiol 2008;37(6):1227-35.
53. De Winter AF, Oldehinkel AJ, Veenstra R, Brunnekreef JA, Verhulst FC, and Ormel J. Evaluation of non-response bias in mental health determinants and outcomes in a large sample of pre-adolescents. Eur J Epidemiol 2005;20(2):173-81.